Prothallus Morphology in some Tectarioid Ferns

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Among the tectarioid ferns, studies of the prothalli have been made in *Arcypteris* and *Pleocnemia* (Atkinson, 1970), *Quercifilix* (Nayar, 1960), and *Tectaria* (Kachroo, 1956; Mahabale & Venkateswaran, 1959; Stokey, 1960; Nayar & Kaur, 1964; Srivastava, 1968). In other tectarioid fern genera no such studies have been made, although Stokey (1960, pp. 82-84) reported the hair types occurring in some genera, including *Ctenitis, Heterogonium,* and *Pteridrys*. The present study concerns ten species of tectarioid ferns: *Ctenitis ampla* (Humb. & Bonpl. ex Willd.) Ching,[2] *C. currori* (Mett. ex Kuhn) Tardieu, *C. eriocaulis* (Fée) Alston, *C. recedens* (J. Smith ex Moore) Copel., *Pteridrys australis* Ching ex C. Chr. & Ching, *Tectaria devexa* (Kunze) Copel., *T. fuscipes* (Wall. ex Bedd.) C. Chr., *T. heracleifolia* (Willd.) Underw., *T. leuzeana* (Gaud.) Copel., and *T. variolosa* (Wall. ex Hook.) C. Chr.

Spores of all the species except *T. fuscipes* and *T. leuzeana* were obtained by Prof. B. K. Nayar, of Calicut University, during his visit to England in 1972 from plants grown at the Royal Botanic Gardens, Kew. Spores of *T. devexa, T. fuscipes,* and *T. variolosa* were taken from plants grown at the National Botanic Gardens, Lucknow. Observations were made on prothalli raised on sterilized Knop's agar medium maintained at 23-25°C under 600 ft-c light intensity for 8 hours daily.

OBSERVATIONS

Prothallus development.—In all the species studied, spore germination (*Figs. 1* and *2*) is of the *Vittaria* type (Nayar & Kaur, 1968), and prothallus development is of the *Aspidium* type (Nayar & Kaur, 1969, 1971). All variations of the Aspidium type of prothallial development were found in all the species studied. The germ filament is usually 2-5 cells long (*Figs. 3* and *4*), as reported in species of *Tectaria* (Nayar & Kaur, 1964), *Quercifilix* (Nayar, 1960), and *Arcypteris* and *Pleocnemia* (Atkinson, 1970). However, the germ filaments may be more than five cells long in *C. eriocaulis* and *T. heracleifolia,* and are up to ten cells in the former species (*Fig. 5*) before any longitudinal divisions occur. Some of the filaments and young prothalli of *C. eriocaulis* and *T. devexa (Figs. 21-23)* produce lateral branches with each branch resembling an individual prothallus, as also has been reported in *T. variolosa* (Nayar & Kaur, 1964).

Plate formation may be initiated by a longitudinal or oblique wall in the terminal cell *(Figs. 7-9),* as also is known in *Tectaria* (Nayar & Kaur, 1964) and in *Arcypteris* and *Pleocnemia* (Atkinson, 1970), or it may be in the penultimate cell *(Figs. 10* and *11),* as in *Quercifilix* (Nayar, 1960) and commonly in *T. variolosa*. Both conditions also have been observed in the prothalli of the same species (e.g., *C. currori, C. eriocaulis, T. devexa, T. fuscipes,* and *T. heracleifolia).*

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[1]The authors are thankful to Dr. T. N. Khoshoo, Deputy Director-in-Charge, National Botanic Gardens, for providing facilities and giving encouragement during the course of this study.
[2]Very likely this plant is the commonly cultivated *C. sloanei* (Poepp.) Morton (see Morton, 1969).

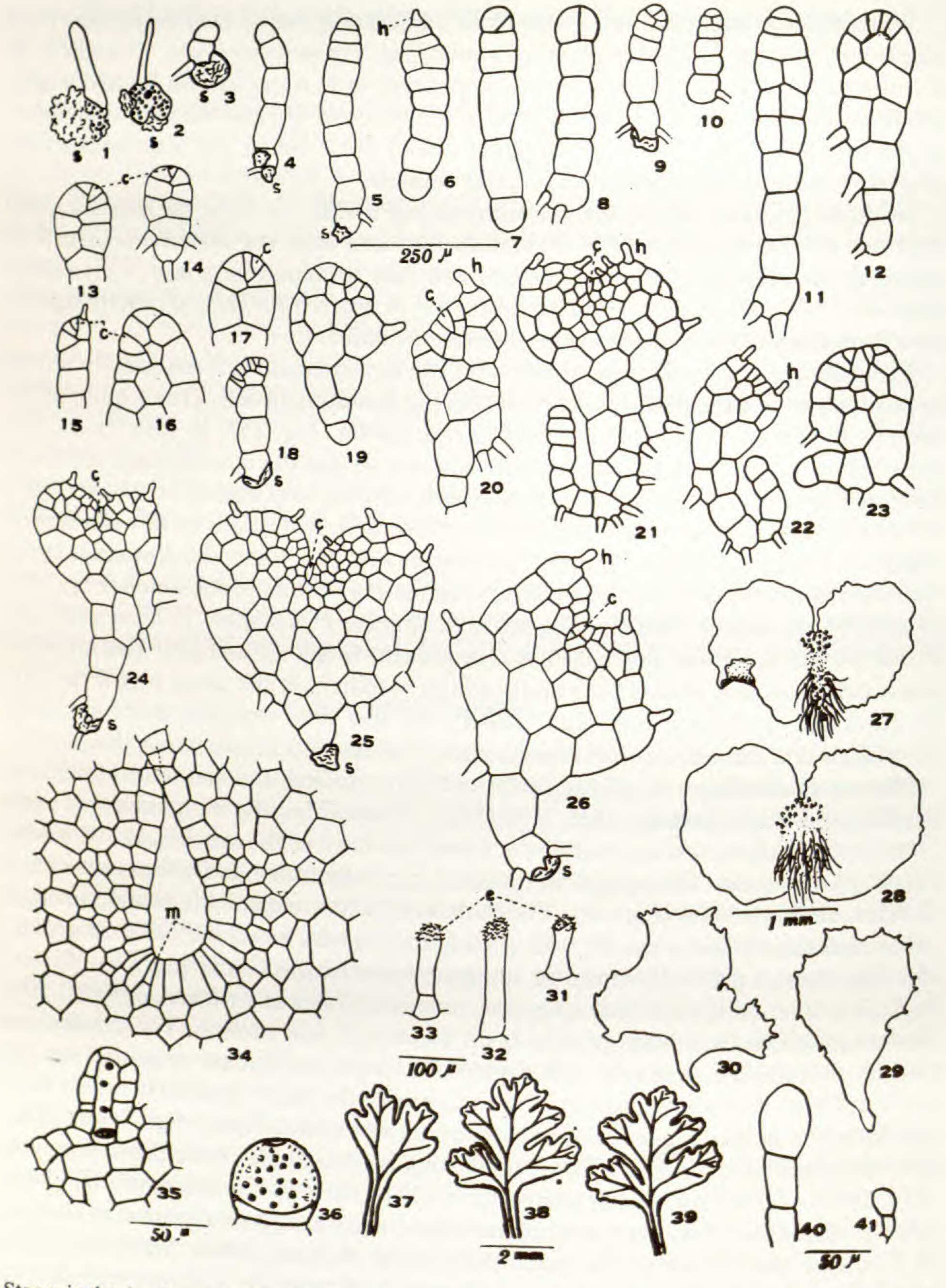
When the meristematic cell forms from the terminal cell, it may be formed by a single wall oblique to the longitudinal wall of the terminal cell *(Figs. 13* and *14)* in *C. currori, T. devexa, T. fuscipes,* or sometimes in *T. heracleifolia* by two walls, the first oblique to the longitudinal wall of the terminal cell and the second oblique to the first *(Fig. 17)*. The other daughter cell of the terminal cell may form a hair (*Fig. 15*); usually hair formation is quite delayed.

In those prothalli where the penultimate cell divides to form the meristic cell, first one of the daughter cells divides further and then the meristematic cell is initiated. In such prothalli the terminal cell may terminate in a hair, as it rarely does in *T. devexa (Fig. 6),* and as described in *Quercifilix* (Nayar, 1960); again, hair formation often is quite delayed *(Figs. 10* and *11)*.

Prothalli are somewhat one-sided, with the meristematic cell not exactly apical in prothalli where the first divisions start in the penultimate cell. This is quite often seen in *T. fuscipes (Fig. 16)* and in *T. heracleifolia (Fig. 18)*. In such cases, the cells below the meristematic cell divide actively so that the meristematic cell soon becomes apical. The obconical meristematic cell actively cuts off daughter cells on either side and the prothallus becomes spatulate with more or less flat apical region in *T. devexa (Fig. 20)* and *T. variolosa (Fig. 19)*. Later the prothallus apex becomes notched, with the meristematic cell at the bottom of the notch *(Figs. 21, 24* and *25)*. In species like *C. eriocaulis, T. devexa, T. fuscipes, T. leuzeana,* and *T. variolosa,* ameristic prothalli are also present (*Figs. 12* and *22*). The meristematic cell soon is replaced by a multicellular meristem in the usual way (*Fig. 26*), as described by Nayar and Kaur (1964). By this time marginal hairs are fully developed and superficial hairs have started to develop.

Mature prothallus.—In all the tectarioid ferns studied, the mature prothallus is cordate and much broader than long *(Figs. 27* and *28)*. The wings overlap each other in the region anterior to the apical notch in most of the species, but do not in *Pteridrys australis*. The apical meristem is normally broad and composed of 6-8 slender, elongate cells *(Fig. 34)*. The midrib is narrow and spindle-shaped in most of the species studied *(Fig. 27),* although it may be very broad in *P. australis (Fig. 28)*. The mature prothallus may be elongate, especially in *C. currori (Fig. 29)* and in *T. fuscipes,* or it may bear irregular, ameristic lobes in *T. leuzeana (Fig. 30)*. Mature prothalli bear hairs profusely on the margin and surface. These hairs are mostly unicellular, sparsely chlorophyllous, and usually are crowned by an extra-cellular, cap-like secretion, and so resemble the hairs reported in most of the aspidiaceous ferns. These hairs may be short and club-shaped *(Fig. 31)* or elongate and papillate *(Fig. 32)*. Two-celled, long hairs *(Fig. 33)* have been observed very rarely. Such hairs are reported to occur in *Pleocnemia conjugata* (Stokey, 1960, p. 83). However, branched, multicellular hairs like those reported in species of *Tectaria* and *Pteridrys* (Stokey, 1960; Nayar & Kaur, 1964; Atkinson, 1973) and long, slender, glandular hairs associated with acicular hairs as reported in *Ctenitis (Lastreopsis) effusa* (Atkinson, 1970, p. 82) have not been observed in the present study.

Sex organs.—In the tectarioid ferns studied, sex organs are similar to those reported earlier in species of *Tectaria*. Antheridia are produced on the lower



Stages in the development of prothalli and juvenile leaves of *Ctenitis*, *Pteridrys*, and *Tectaria*. FIG. 1. Vittaria-type germination in spores of *C. recedens*. FIG. 2. Same, *C. eriocaulis*. FIG. 3. Germ filaments of *C. recedens*. FIGS. 4, 5. Same, *C. eriocaulis*. FIG. 6. Germ filament of *T. devexa* surface of the prothalli soon after the apex of the prothallus becomes cordate and are restricted to the midrib region. Under crowded conditions, antheridia are also produced by germ filaments even before the cell plate is formed, and so are marginal. Archegonia are formed later than antheridia and are superficial on the lower surface in the region of the midrib near the apical notch. Antheridia are globose *(Fig. 36)* with the basal cell usually saucer-shaped. Archegonia possess short, slightly curved necks which generally are 3-5 cells long *(Fig. 35)*.

Juvenile leaves.—Among the species studied, only *C. ampla* and *C. recedens* produced juvenile sporophytes. Fertilization takes place 5-6 months after the spores are sowed, and young sporophytes are soon formed. The first juvenile leaf is obcuneate with a single, dichotomously divided vein, as shown in species of *Tectaria* (Nayar & Kaur, 1964) and *Pleocnemia* (Atkinson, 1970). Soon the lamina becomes lobed, and the single-forked vein divides dichotomously so that each ultimate vein supplies a single lobe (*Fig. 37*). The lamina margin becomes considerably lobed, and the midrib forms (*Fib. 38*), usually by the fourth or fifth leaf, as also has been described in *Tectaria* (Nayar & Kaur, 1964) and *Pleocnemia* (Atkinson, 1970). By approximately the eighth leaf, the lamina becomes pinnate with simple venation (*Fig. 39*), as described in *T. fuscipes*. Unicellular and multicellular uniseriate hairs similar to those present on the prothalli cover the stipes and laminae of the juvenile leaves. In addition, some very small, two-celled, club-shaped (*Fig. 41*) and three-celled, elongate (*Fig. 40*) hairs also occur on the juvenile leaves.

CONCLUSIONS

The present study has shown that the types of spore germination and prothallial development are similar in all the tectarioid fern genera studied. Branched hairs reported earlier in *Tectaria* (Nayar & Kaur, 1964), *Pteridrys* and *Heterogonium* (Stokey, 1960, pp. 83, 84; Atkinson, 1970, p. 82), and *Quercifilix* (Nayar, 1960) are absent in the species of the present study, as they are in *Pleocnemia* and *Arcy-*

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showing terminal hair. FIGS. 7, 8. Germ filaments showing initiation of plate formation in the terminal cell in *T. fuscipes*. FIG. 9. Same, *T. heracleifolia*. FIG. 10. Germ filament showing initiation of plate formation in the penultimate cell of *T. heracleifolia*. FIG. 11. Same, *T. devexa*. FIG. 12. Ameristic thallus of *T. fuscipes*. FIGS. 13, 17. Young prothalli showing formation of the meristematic cell of *T. devexa*. FIG. 14. Same, *C. currori*. FIG. 15. Same, *C. eriocaulis*. FIG. 16. Same, *T. fuscipes*. FIG. 18. Same, *T. heracleifolia*. FIG. 19. Spatulate prothalli showing flat apical region in *T. variolosa*. FIG. 20. Same, *T. devexa*. FIGS. 21, 22. Branched prothalli of *C. eriocaulis*. FIG. 23. Same, *T. devexa*. FIG. 24. Young prothalli showing meristematic cell at the bottom of the apical notch in *P. australis*. FIG. 25. Same, *C. currori*. FIG. 26. Young prothallus of *T. variolosa* showing initiation of replacement of meristematic cell by multicellular meristem. FIG. 27. Mature prothallus of *C. eriocaulis*. FIG. 28. Same, *P. australis*. FIG. 29. Same, *C. currori*. FIG. 30. Same, *T. leuzeana*. FIGS. 31-33. Marginal hairs on the prothalli of *C. recedens*. FIG. 34. Portion of a mature prothallus of *C. ampla* showing multicellular meristem. FIG. 35. Vertical section through the archegonium of *C. ampla*. FIG. 36. Mature antheridium of *P. australis*. FIGS. 37-39. Stages in the development of juvenile leaves of *C. ampla*. FIGS. 40, 41. Hairs on the juvenile leaves of *C. recedens*. The abbreviations are: c = meristematic cell, e = extracellular cap, h = hair, m = multicellular meristem, and s = spore.

pteris (Atkinson, 1970). However, prothalli of five species of *Tectaria* in Stokey's cultures did show the presence of multicellular or branched hairs or both (Stokey, 1960). Thus Stokey's observations and the present ones are in agreement that the occurrence of branched hairs on tectarioid prothalli does not happen regularly.

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